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Tech Notes

Multifunction Phased Array Radar Panel

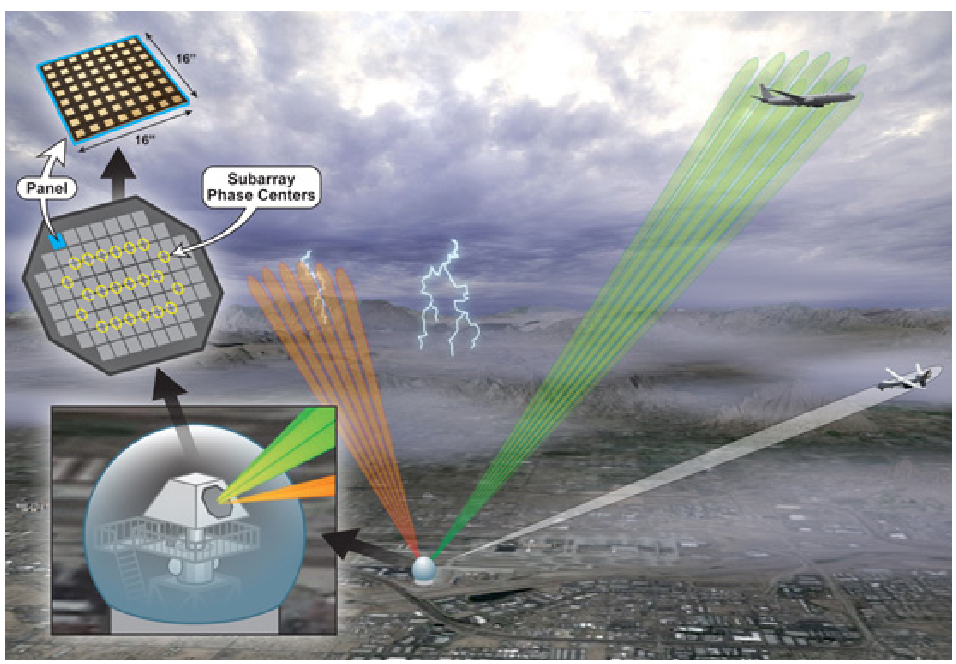
An innovative design exploits dual polarization and digital beamforming to provide a radar solution for simultaneous aircraft surveillance and weather sensing

Most people immediately recognize the importance of radar systems to the Federal Aviation Administration (FAA), which relies on radar to track and manage air traffic, and to the National Weather Service, which provides forecasts and emergency weather information. Yet, the National Aeronautics and Space Administration, the Departments of Agriculture and Homeland Security, the Environmental Protection Agency, and other federal agencies depend on civilian networks of eight distinct radar systems for a wide variety of information: identification and tracking of vehicles, radar imaging from space, and climate data, to name a few. However, these 10- to 40-year-old systems are nearing the end of their designed lifespans.

MIT Lincoln Laboratory has proposed a multifunction phased-array radar (MPAR) system as the replacement for the aging systems. Unlike the current civilian radar systems that use rotating dish antennas, the MPAR system has no moving parts, instead utilizing four antenna faces for 360° scanning, and electronically shapes its radar beam. The MPAR's resulting beam agility permits faster full-volume scan rates and increased resolution, and enables one radar unit to perform various weather and aircraft surveillance tasks. In addition, an MPAR system's surveillance capabilities would likely exceed those of current radar systems by allowing more frequent weather scans and providing vertical resolution and height estimates for aircraft.

The Key to the MPAR System

Under FAA sponsorship, Lincoln Laboratory and M/A-COM jointly developed a prototype of an active electronically scanning phased-array antenna panel, which is the fundamental building block of an MPAR system.



The illustration shows how the multifunction phased-array radar panel provides a solution for simultaneous aircraft surveillance and weather sensing.

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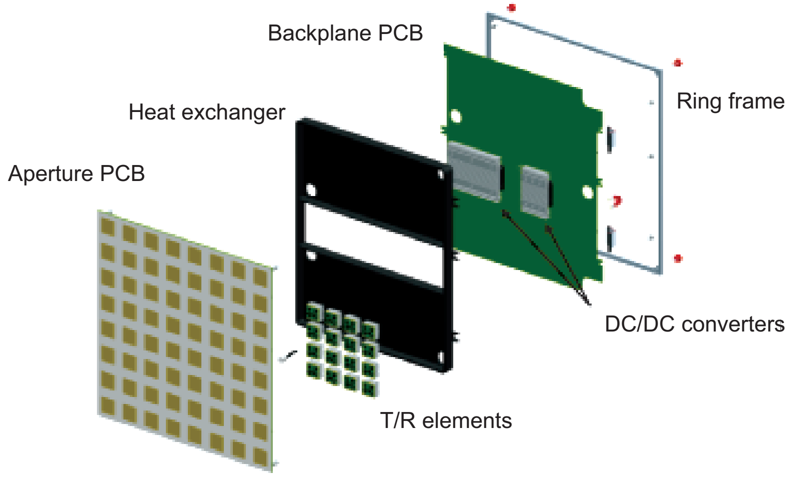
Each panel is made up of an aperture printed circuit board (PCB), a heat exchanger, and a backplane PCB that distributes DC power and control to the array elements (see exploded view of the MPAR panel at right). The aperture PCB incorporates the microstrip antenna patch elements, the antenna feed network, the array beamforming networks, the DC-power-distribution network, and the control-signal distribution network. The PCBs are made up of commercially available microwave circuit board materials and are constructed using standard commercial manufacturing techniques.

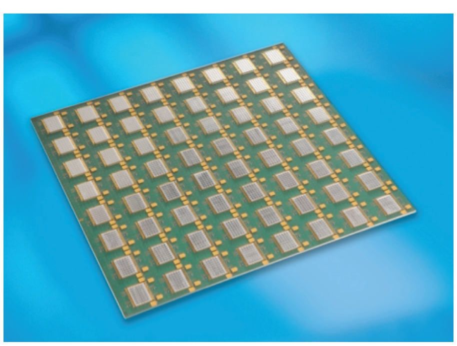
Each MPAR panel has 64 antenna elements, each of which has a separate radiator and a transmit-receive (T/R) module that amplifies the radar signal and controls the phase of the signal relative to the other elements of the panel. The 64 transmit-receive modules are surface-mounted onto the back of the aperture board.



Exploded view of the MPAR panel.

The phased-array panels function together coherently to radiate and receive pulses of radar energy that can be used to detect, locate, and track aircraft and weather targets.

To achieve the required polarization performance, the researchers implemented a unique transmit-receive module architecture that has (1) two independent transmit channels and (2) two independent receive channels with switchable beamformer paths. This architecture allows the module to be rapidly reconfigurable to output either a single dual-polarized receive signal or two independently steered linearly polarized signals. The MPAR system's ability to output twice as many simultaneous linearly polarized radar beams as dual-polarized beams improves radar resource management.



Back side of the prototype MPAR panel.

To operate the panels as a phased-array radar, a set of the panels (~300 units) is integrated into a planar configuration to form a single radar antenna face. The active phase and amplitude control at the element level of an array provides the ability to electronically steer the direction of radar signals transmitted from and received by the aperture. A beamforming network coherently distributes the signals to individual elements during transmit mode and coherently combines the energy during receive mode.

The phased-array panels function together coherently to radiate and receive pulses of radar energy that can be used to detect, locate, and track aircraft and weather targets.

Advantages of an MPAR System

The capabilities of an MPAR system may afford significant benefits for weather and aircraft surveillance. The system could identify severe weather activity earlier, improve rainfall predictions and flash flood warnings, and provide better data to initialize runs of numerical weather-prediction models. Improved forecasting of severe weather would increase safety and decrease delays for air travel, and monitoring of the U.S. airspace would benefit from enhanced aircraft detection and tracking.

An MPAR system would also be cost-effective. According to the government's *Report of the Joint Action Group for Phased Array Radar Project,* because of the MPAR's ability to perform weather and aircraft surveillance simultaneously, an MPAR network would reduce the number of radar units needed in the United States from the more than 500 currently in use to 330. In addition to the savings realized by the acquisition of fewer new systems, MPAR's use of standard materials and manufacturing methods from the commercial wireless industry, along with its scalable array architecture, would result in substantial savings for operation and maintenance over the 30-year lifespan of the radars. ■

Additional Reading

M. Weber, J. Cho, J. Flavin, J. Herd, and M. Vai, "Multi-function Phased Array Radar for U.S. Civil Sector Surveillance Needs," 32nd Conference on Radar Meteorology, 22–29 October 2005, American Meteorological Society, 2005.

M. Weber, "Advances in Operational Weather Radar Technology," *Lincoln Laboratory Journal,* vol. 16, no. 1, 2006, pp. 9–30.

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